

MAP65 User's Guide

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Introduction

[MAP65](#) is a computer program designed for EME communication using the JT65 protocol. When used with RF hardware providing coherent signal channels for two orthogonal polarizations, the program offers automatic polarization-matched reception for every JT65 signal in a 90 kHz passband. Where linear polarization is in use, *MAP65* eliminates the effect of mismatched polarization angles on reception, so you are never faced with Faraday lockout or one-way propagation. On bands where circular polarization is the norm, *MAP65* is highly effective in its single-channel mode — again providing visual display of all signals in a 90 kHz window and decoding all the JT65 signals.

Hardware and Software Requirements

MAP65 requires specialized receiver hardware to convert an RF band to a digitized I/Q (in-phase and quadrature) data stream at baseband. The program was originally designed for use with the [WSE converters](#) designed by Leif Asbrink, SM5BSZ, together with his [Linrad](#) software. *Linrad* controlled the WSE hardware and handled the data acquisition tasks, forwarding digital data to *MAP65*. These choices remain good ones, but today there are many other possibilities. *MAP65* can be used with the [SoftRock](#), [FUNcube Dongle](#), [SDR-IQ](#), [Perseus](#), [IQ+](#) and other comparable receiver hardware. These receiver types have different interfacing requirements, summarized below. Some are usable with [SDR-Radio](#) as an alternative to *Linrad*, or with *MAP65* in its stand-alone mode.

The SoftRock, IQ+, and WSE receivers mix signals from RF to baseband and use a computer soundcard for the analog-to-digital conversions. The FUNcube Dongle has a built-in silicon tuner and its own A/D converters; it plugs into a computer's USB port and presents itself to the operating system as a two-channel audio input device. The SDR-IQ and Perseus receivers do their A/D conversions at RF and accomplish down-conversion digitally, in a field-programmable gate array. Any of these systems, and many others with comparable features, can be used with *MAP65*. Obviously, those designed for input frequencies in the HF range will require another receive converter mixing down from the VHF/UHF band of your choice to, say, 28 MHz.

The SoftRock, FUNcube Dongle, SDR-IQ, and Perseus are all single-channel receivers, so they cannot support adaptive polarization. You could, however, configure a pair of modified SoftRocks (or approximate equivalents) for use in a dual-polarization system. They would need to be driven by a single local oscillator, to maintain coherence

between the two RF channels. The IQ+ and WSE converters are high-performance, two-channel systems that can support adaptive polarization directly.

Some example receivers and their interfacing requirements are summarized in Table 1. The SoftRock, FUNcube Dongle, and IQ+ use programmable synthesizers for their local oscillators. Their input frequencies can be set from within *Linrad*, *SDR-Radio*, or *MAP65* via a USB port. Center frequencies for the SDR-IQ and Perseus receivers are set in the same way, although in these cases the “local oscillator” is a numerically controlled oscillator (NCO) implemented in software. To achieve very low phase noise and high spurious-free dynamic range, the WSE converters use a sequence of switchable crystal oscillators for frequency control. Their switching is accomplished from within *Linrad* through the computer’s parallel port.

Table 1: Examples of receiving equipment and configurations for use with MAP65, with interfacing requirements

	SoftRock	FUNcube Dongle	SDR-IQ, Perseus	SoftRock × 2	IQ+ VL, V, U	WSE
Input Freq (MHz)	28, 144	144, 432, 1296	28	28, 144	50, 144, 432	144
Polarizations	1	1	1	2	2	2
Soundcard Channels	2	–	–	4	4	4
Digital Interface	USB	USB	USB	USB	USB	Parallel Port
Frequency Control*	L, S, M	L, S, M	L, S	L, M	L, M	L
Front-End Software*	L or S optional	–	L or S required	L optional	L optional	L optional

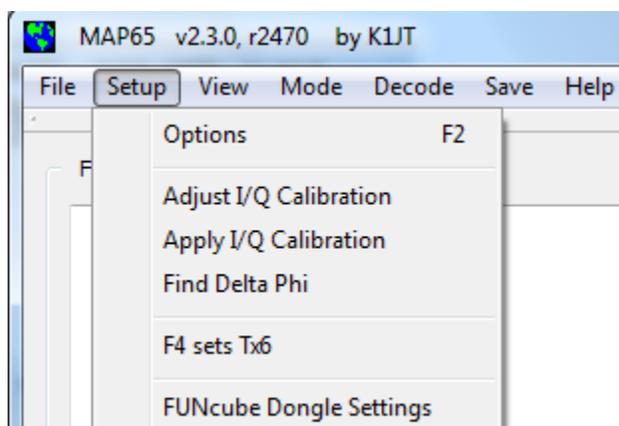
* L = *Linrad*, S = *SDR-Radio*, M = *MAP65*

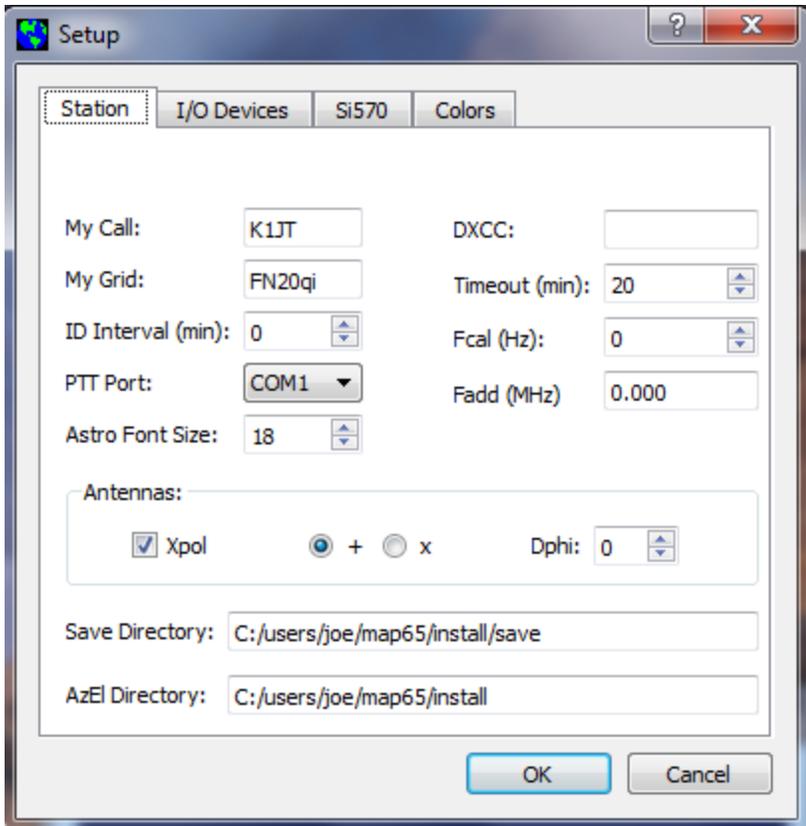
Using *Linrad* as a data-acquisition front end provides some significant advantages. Its noise-blanking capabilities are superb. It provides many flexible configuration options and other receiver amenities including mode-specific demodulation and audio output to headphones or speaker. It interfaces directly to the SDR-IQ and Perseus receivers, handling their necessary control and data acquisition tasks. In single-polarization systems, *SDR-Radio* can manage the data input and control functions, again providing demodulation and audio output and forwarding wideband digital data to *MAP65*. *SDR-Radio* is polished, commercial-quality software available free to hams, and some have found it an easy way to get started with *MAP65*. Finally, *MAP65* can be used in stand-alone mode with I/Q signal inputs taken directly from a soundcard or a FUNcube

Dongle. Stand-alone operation of *MAP65* with the IQ+ receiver is a particularly attractive option for a low-cost, high-performance system for digital EME.

Installation and Setup

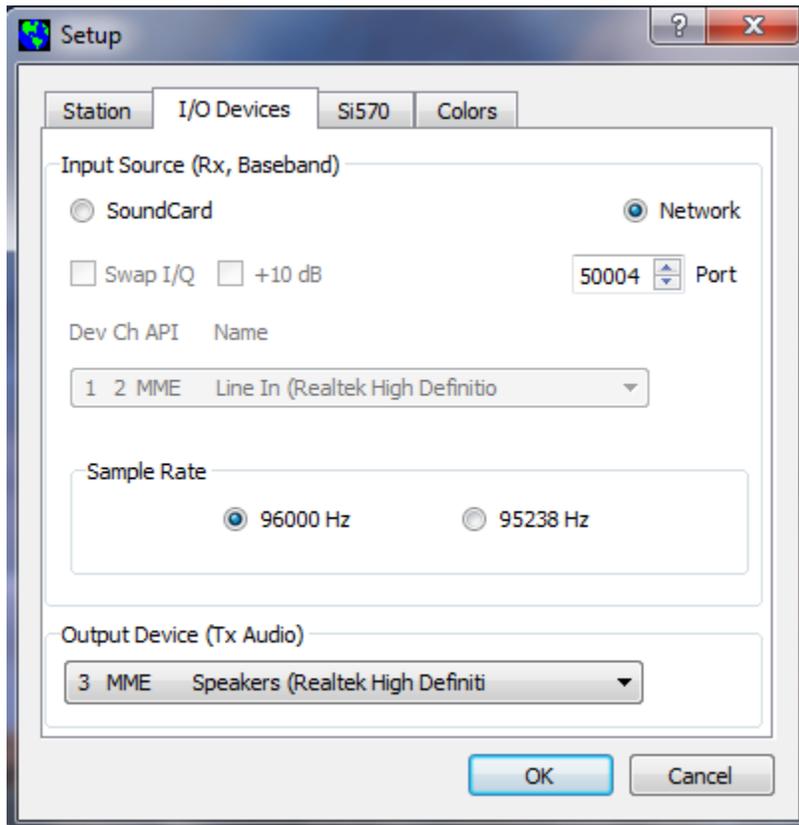
1. Use something like “C:\MAP65” or “C:\Radio\MAP65” rather than “C:\Program Files\MAP65” for the installation directory. All *MAP65* files are normally located in the installation directory and its subdirectories; the program can be uninstalled by deleting these directories and their contents.
2. Download and install MAP65 from a link on the following page:
<http://www.physics.princeton.edu/pulsar/K1JT/map65.html>
3. On the final screen of the installation wizard you will be offered a chance to run a program that configures optimized FFT routines for your particular computer. Choosing the first (default) checkbox will be adequate for most purposes, and will result in an optimization process that proceeds silently for several minutes. Be sure to allow the optimization procedure to finish before proceeding.
4. Start MAP65 by clicking on its desktop icon.
5. Open the **Setup | Options** screen and select the **Station** tab (see screen shot on next page). Enter your callsign, grid locator, and other parameters as required for your station. Be sure to check **Xpol** if yours is a dual-polarization system, and uncheck it for single polarization.





6. If you will be using *Linrad* or *SDR-Radio* for data acquisition, the box labeled **Fadd** can be used to enter a nominal difference between the frequency reported by that program and your corresponding on-the-air frequency. For example, if your RF chain converts 144 to 28 MHz, enter 116.0 for **Fadd**. For now you can leave parameters **Fcal** and **Dphi** set to zero. You may wish to optimize their values later.

7. Select the **I/O Devices** tab:

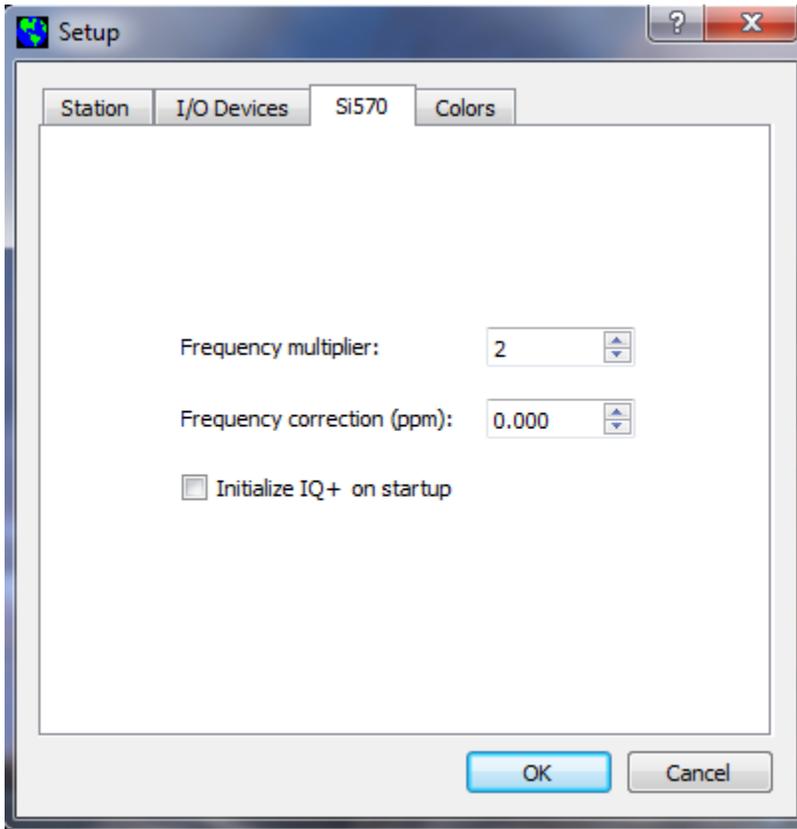


If you will use sound card input or a FUNcube Dongle, check **SoundCard** and choose the proper audio input device from the drop-down list. Depending on your hardware setup, it might be necessary to check the **Swap I/Q** box. If you will use *Linrad* or *SDR-Radio* for data acquisition, check **Network** and select the correct input sample rate for your hardware — either 96000 or 95238 Hz. These are the only sample rates supported by *MAP65*. You might need to change the network **Port** number from the default value 50004, so as to match the port being used by *Linrad* or *SDR-Radio*. Finally, select the output device you wish to use for Tx audio.

8. If your receiver uses the Si570 synthesizer chip and you want MAP65 to be able to set its frequency, go to the **Si570** tab and set the parameters **Frequency multiplier** and **Frequency correction (ppm)** as required. The IQ+ receiver uses a frequency multiplier of 2, while the SoftRock uses 4. If you have determined that the Si570 master oscillator is slightly off frequency, you can enter a suitable correction in parts per million (ppm). The commanded Si570 frequency will be

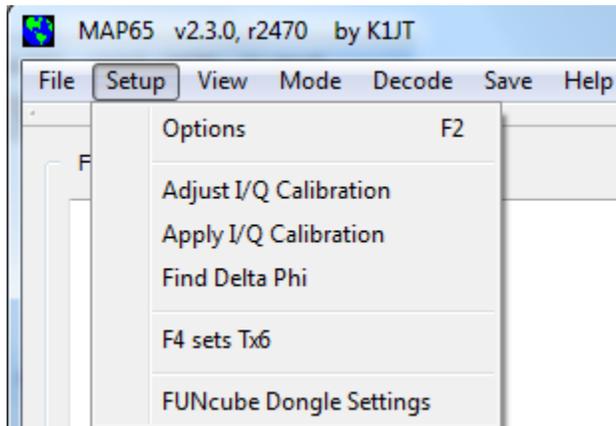
Multiplier $\times (1.0 + 0.000001 \times \text{Correction}) \times \text{ForceCenterFrequency}$

where ForceCenterFrequency is a value (in MHz) entered in a box at bottom right of the Wide Graph window. Be sure to check the box labeled **Initialize IQ+ on startup** if you want your IQ+ receiver to be reset each time MAP65 starts.

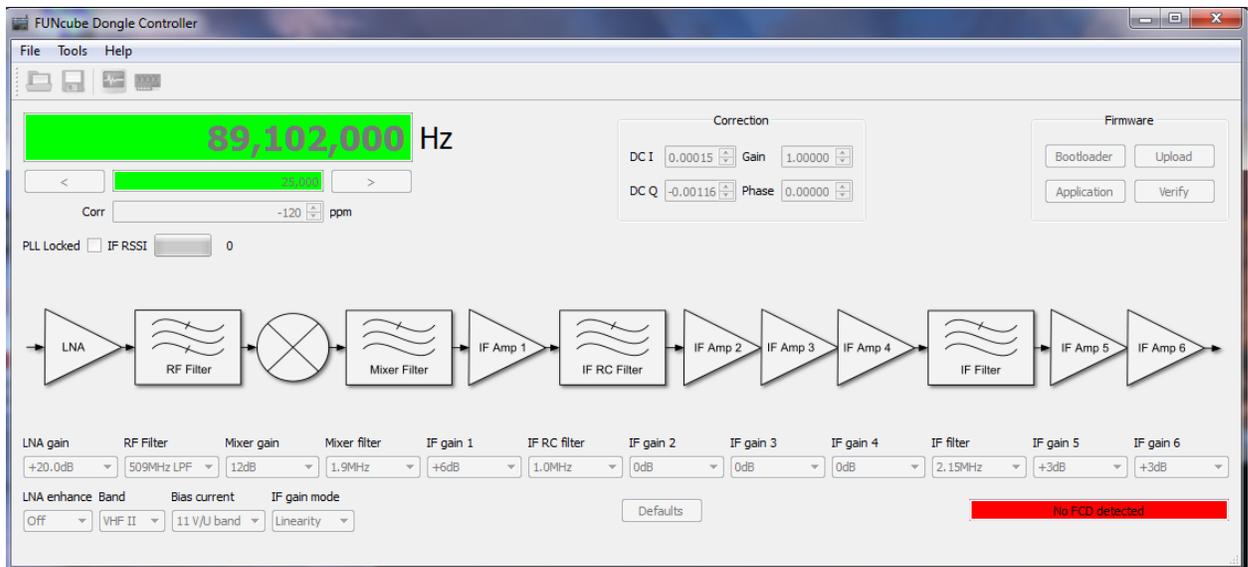


9. Click **OK** to dismiss the Setup dialog window.

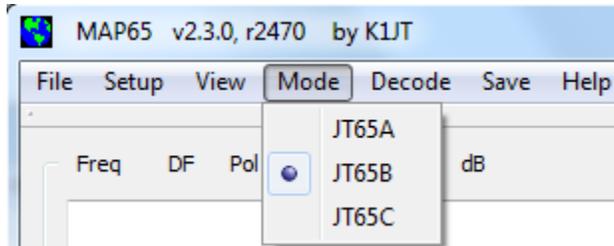
10. If you are using a FUNcube Dongle, you can set its parameters by clicking the item **FUNcube Dongle Settings** on the **Setup** menu.



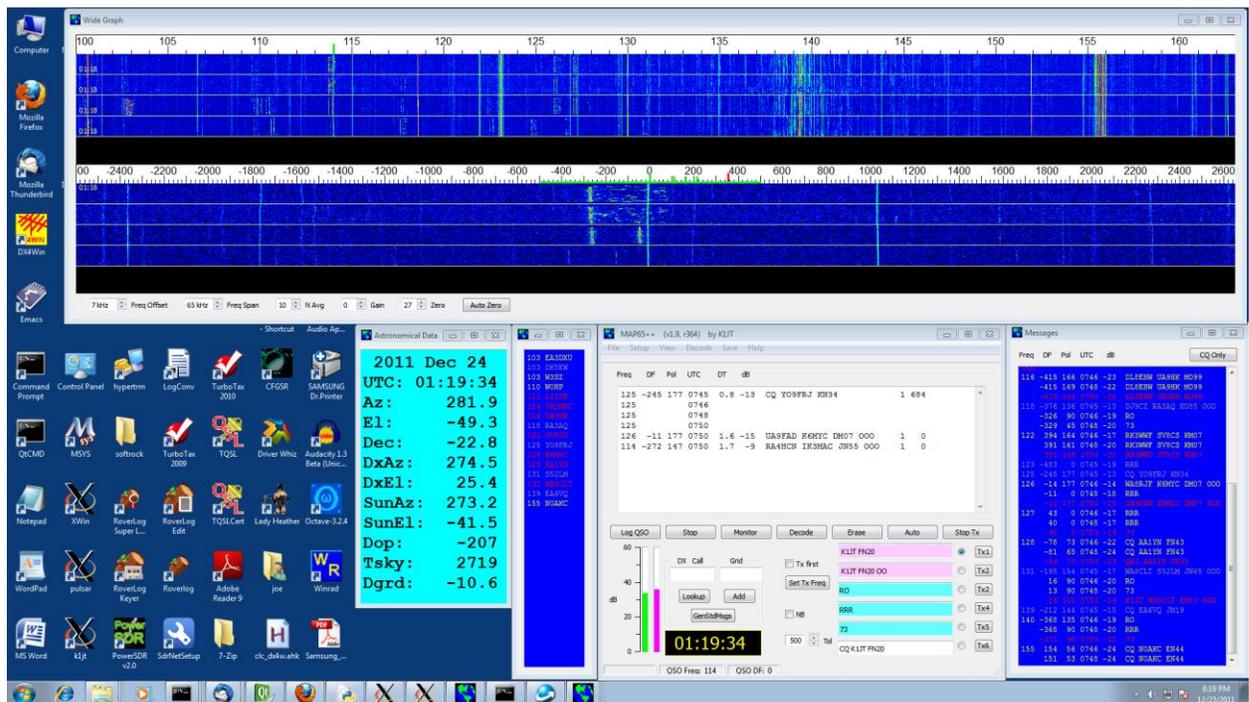
This action will start a program that you can use to configure your FUNcube Dongle. Detailed instructions can be found [here](#).



11. On the **Mode** menu, select JT65 sub-mode A, B, or C. By convention JT65A is generally used for EME on 50 MHz, JT65B on 144 and 432 MHz, and JT65C at 1296 MHz and above.



12. Position the five main windows of MAP65 as you wish, possibly resizing some of them as desired. As an example, my typical screen setup looks something like this:



13. If you will be using *Linrad* or *SDR-Radio*, start that program and be sure it is configured to send data packets to *MAP65* on the port number you selected in step 7. In *Linrad*, you want the “timf2” data packets. When everything is working properly the vertical thermometer bars (at lower left of the main window) should show signal levels around 20–30 dB. Click the **Auto Zero** button at the bottom of the waterfall window to adjust its zero level. If you are using soundcard input or a FUNcube Dongle, enter the center frequency (for example, 144.125) at bottom

right of the Waterfall and check the box labeled **Force Center Freq (MHz)**. This is the frequency converted by your receiver hardware to zero frequency in the I/Q baseband data. If you are using the IQ+ receiver, click **Set Rx Freq** to command the receiver's Si570 synthesizer to the correct frequency.

14. Adjust the spinners labeled **Freq Span** and **Freq Offset** for the most pleasing display of the desired portion of the band. For normal EME activity on the 2m band you will probably want to display a range something like 144.100 to 144.160, which shows on the screen as 100 to 160. On 432 or 1296 MHz, an appropriate range is something like 0 to 90 (i.e., 432.000 to 432.090, etc.).

You should now be ready to use *MAP65*.

Decoding Tutorial

The best way to become familiar with *MAP65* is to play with some recorded data files. The program's wideband capability means that its recorded data files are large — about 20 MB per minute for single-polarization data, 40 MB for dual polarization. Compressed versions of one such file with dual-polarization data are available at http://physics.princeton.edu/pulsar/K1JT/061111_0746.tf2.zip (for Windows, 25.3 MB compressed) and http://physics.princeton.edu/pulsar/K1JT/061111_0746.tf2.bz2 (for Linux, 20.7 MB compressed). Download and decompress one of these files to produce a file named 061111_0746.tf2.

Start *MAP65*. On the **Setup | Options** screen, check **Xpol** and set **Dphi** = -50 so your settings will be consistent with those of the system that made the example recording. On the Wide Graph window, set **Freq Span** = 60 kHz, **N Avg** = 10, and **Zero** = 26. Check **NB** on the main window to turn on the noise blanker. Select **File | Open**, navigate to where you extracted the file 061111_0746.tf2, and open it.

In a short time (perhaps 5-20 s, depending on the speed of your computer) the text reproduced below should appear in the Messages window. *MAP65* decodes EME transmissions from 16 different stations in this one-minute interval. W3SZ is detected and decoded twice: his tropospheric signal at DF=360 Hz and EME signal at DF=471 Hz overlap in frequency as well as time, but *MAP65* decodes them correctly anyway.

Freq	DF	Pol	UTC	dB					
101	113	0	0746	-19	RRR				
103	155	135	0746	-13	RO				
	360	152	0746	-5	DK5EW W3SZ FN20			H	
	471	58	0746	-21	DK5EW W3SZ FN20			V	
110	321	56	0746	-18	LX/PA3FPQ W0HP				
	485	135	0746	-14	73				
111	-17	90	0746	-17	RRR				
114	367	135	0746	-6	73				
116	218	167	0746	-23	DL8EBW UA9HK MO99			H	
118	307	90	0746	-19	RO				
123	21	159	0746	-17	RK3WWF SV8CS KM07			V	
127	-381	174	0746	-14	WA8RJF K6MYC DM07 OOO			H	
128	-327	135	0746	-11	RRR				
129	-448	67	0746	-21	CQ AA1YN FN43			V	
132	-357	90	0746	-17	RO				
140	262	90	0746	-20	RO				
156	-216	54	0746	-23	CQ N0AKC EN44			H	

MAP65 does a quick decode at the selected QSO frequency before processing the wideband data. At program startup the QSO frequency defaults to the center of the displayed region, in this case 144.125 MHz. Nobody was transmitting an EME signal at

144.125 at 0746 UTC on November 11, 2007, so in the main text window you should see a single line indicating that no JT65 signal was found at the selected QSO frequency at 0746:

125 0746

Quick decodes can be done at other frequencies by clicking on the desired frequency in the waterfall and then on **Decode**, or simply double-clicking on the desired frequency. Either action resets the QSO frequency and then invokes the quick decoder. Note that you can click to select a signal on either the upper (wideband) or lower (zoomed) waterfall.

Double-click on the upper waterfall at each of the frequencies 101, 103, 110, 111, 114, 116, 118, 123, 127, 128, 129, 132, 140, and 156. Your main text window should now look something like the following:

Freq	DF	Pol	UTC	DT	dB				
125			0746						
101	113	0	0746	2.3	-19	RRR	0	0	0
103	155	135	0746	1.9	-13	RO	0	0	0
103	360	152	0746	0.3	-5	DK5EW W3SZ FN20	1	0	152 H
103	471	58	0746	2.8	-21	DK5EW W3SZ FN20	1	0	58 V
110	321	56	0746	2.9	-18	LX/PA3FPQ W0HP	1	0	0
110	485	135	0746	1.9	-14	73	0	0	0
111	-17	90	0746	2.3	-17	RRR	0	0	0
114	367	135	0746	1.9	-6	73	0	0	0
116	218	167	0746	1.8	-23	DL8EBW UA9HK MO99	1	0	24 H
118	307	90	0746	2.3	-19	RO	0	0	0
123	21	159	0746	2.9	-17	RK3WWF SV8CS KM07	1	0	86 V
127	-381	174	0746	2.4	-14	WA8RJF K6MYC DM07 OOO	1	0	147 H
128	-327	135	0746	1.9	-11	RRR	0	0	0
129	-448	67	0746	2.8	-21	CQ AA1YN FN43	1	0	61 V
132	-357	90	0746	2.1	-17	RO	0	0	0
140	262	90	0746	2.3	-20	RO	0	0	0
156	-216	54	0746	3.4	-23	CQ N0AKC EN44	1	0	40 H

You might be interested to see specific examples of the difference between single-polarization and dual-polarization reception. A single-polarization version of the example data file can be downloaded from the following link: http://physics.princeton.edu/pulsar/K1JT/061111_0746.iq.zip. Download and decompress one of this file to produce a file named 061111_0746.iq. (It contains exactly the same data as the dual-polarization file 061111_0746.tf2 for horizontal polarization, but data from the vertical receiver has been removed.) Hit the **F2** key to open the **Options** window, and uncheck the **Xpol** box. Select **Erase Band Map and Messages** on the File menu, to clear those windows; then select **File | Open**, navigate

to the directory where you extracted the file 061111_0746.iq, and open it. After a few seconds the following text should appear in the Messages window:

Freq	DF	Pol	UTC	dB	
103	155	0	0746	-14	RO
	354	0	0746	-6	DK5EW W3SZ FN20
110	324	0	0746	-22	LX/PA3FPQ W0HP
	485	0	0746	-14	73
114	367	0	0746	-7	73
116	218	0	0746	-23	DL8EBW UA9HK MO99
123	21	0	0746	-17	RK3WWF SV8CS KM07
127	-381	0	0746	-14	WA8RJF K6MYC DM07 OOO
128	-327	0	0746	-16	RRR
132	-357	0	0746	-21	RO
156	-216	0	0746	-25	CQ N0AKC EN44

Only 10 EME transmissions are copied, compared with the 16 that were copied with the advantage of adaptive polarization. (The transmission copied here from W3SZ is his terrestrial signal, not the EME signal.) This example is typical, but certainly not extreme. On 144 and 432 MHz, a receiver with adaptive polarization capability can double the number of EME signals you can copy at any particular time. For signal levels close to the decoding threshold, the ratio can be even higher.

If you are an experienced user of *WSJT* and *JT65*, you should now know enough to be able to use *MAP65*.

Additional Features and Options

(Text still to be added ...)

